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TERRESTRIAL AIR QUALITY STUDIES in the vicinity of HEMLO GOLD MINES

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Ministry of the Environment

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Acting Director
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TERRESTRIAL AIR QUALITY STUDIES
in the vicinity of the
HEMLO GOLD MINES
1986

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TECHNICAL SUPPORT SECTION
NORTHWESTERN REGION
ONTARIO MINISTRY OF THE ENVIRONMENT
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SOMMAIRE

En 1984, on a commencé l'exploitation de trois mines d'or, près d'Hemlo, sur la rive nord du Lac Supérieur. Il s'agit des mines Lac Minerals Limited (Page-Williams Mine Division), Hemlo Gold Mines Inc. (Golden Giant Mine) et Teck Corona Operating Corporation. Situées à environ 50 kilomètres à l'est de Marathon (Ontario), ces mines voisines sont près de l'autoroute 17.

La même année, avant l'ouverture des mines, le Ministère a effectué des études sur les écosystèmes terrestres à Hemlo. Les concentrations de polluants en suspension dans l'air qui ont été mesurées dans le sol et la végétation environnants étaient conformes à la courbe normale des concentrations de fond.[1] On a répété cet échantillonnage en 1986, époque à laquelle les trois mines étaient en activité; puis, on a comparé ces résultats à ceux de 1984.

L'étude révèle que les concentrations d'aluminium, d'antimoine, d'arsenic, de baryum, de fer, de mercure, de molybdène et de vanadium présentes dans les lichens, les mousses et le feuillage ont augmenté considérablement par rapport à 1984, avant que ne commence l'exploitation des mines. Il semblerait que la principale source de pollution soit la mine Lac Minerals Limited et, plus précisément, l'explosion de rochers pendant les travaux de construction et pendant les activités minières à ciel ouvert. Étant donné que la construction de la mine est terminée et que l'on a enlevé tous les minerais de surface, il ne devrait plus y avoir d'explosions.

Pour s'assurer qu'il n'y a plus de préoccupations à l'égard de la qualité de l'air près des mines d'Hemlo, le Ministère entreprendra en 1988 une étude de suivi à petite échelle.

INTRODUCTION

In 1984, development of three gold mines began near Hemlo on the north shore of Lake Superior. The three mines are Lac Minerals Limited (Page-Williams Mine Division), Hemlo Gold Mines Inc. (Golden Giant Mine), and Teck Corona Operating Corporation. These mines are all close to one another and are adjacent to Highway 17, approximately 50 kilometres east of Marathon, Ontario.

The Ministry conducted terrestrial studies at Hemlo in 1984, before the mines were in production. Levels of potential airborne contaminants from mining operations were within normal background ranges in local vegetation and soil.[1] This sampling program was repeated in 1986, when all mines were operating. These results were then compared with the 1984 pre-operational data.

METHODS

In June, 1986, samples were collected of one and two-year-old white or black spruce foliage, moss (Pleurozium schreberi), lichens (Evernia mesomorpha and Usnea sp.), and two depths of soil (0-5 and 5-10 cm). Standard Ministry sampling procedures were followed.[2] The fourteen sampling sites near the mines (Figure 1), as well as the two controls, were the same as those used in 1984. All samples were analyzed for aluminum, antimony, arsenic, barium, cadmium, copper, iron, mercury, molybdenum, titanium, vanadium and zinc. In addition, organic matter and pH were determined for soil samples. Analyses were performed at Ministry laboratories in Thunder Bay and Toronto.

Vegetation in the vicinity of sample sites was examined for visible evidence of stress caused by insects, contaminants or physiological factors.

Contaminant guidelines developed by the Ministry for soil are used in this report. Their exceedence suggests that contamination may be present, but does not necessarily imply adverse effects. Guidelines for contaminants in conifer foliage, mosses and lichens have not yet been established.

RESULTS

VEGETATION

No serious insect or disease problems were encountered in vegetation at any of the sampling locations. Minor defoliation of white and black spruce by spruce budworm was noted. There were no visible symptoms of air pollution injury.

Chemical analysis results are summarized in Table 1. Many elements (those shown in Table 2) increased in concentration from 1984 to 1986. There were no significant differences in levels of cadmium, copper, titanium, or zinc between the two years. The 1986 distribution of arsenic in P. schreberi is plotted in Figure 2. A similar pattern was found for aluminum, antimony, barium, mercury, iron and vanadium in P. schreberi, E. mesomorpha and Usnea. While contaminant levels in spruce foliage were also higher in 1986 than in 1984, the differences were less pronounced than those for moss and lichens.

A correlation matrix between pairs of elements in Pleurozium schreberi is presented in Table 3 for 1986 data. Strong positive linear relationships existed between aluminum, antimony, arsenic, barium, iron, mercury, molybdenum and vanadium. These relationships suggest that these contaminants originated from a common source. There were strong negative relationships between these contaminants and distance from the Lac Minerals headframe. Slightly weaker correlations were found with distance from the Lac Minerals open pit area. These findings suggest that the Lac headframe area was a primary contamination source, and the pit area was a secondary

source. There were only two elements (aluminum and vanadium) which had strong negative correlations with distance from the Golden Giant Mine, and none were correlated with respect to distance from Teck-Corona.

SOIL

Chemical analysis results for soil are summarized in Table 4. Except for copper, average concentrations of elements in soil did not change significantly from 1984 to 1986. There were four exceedences of the copper guideline and one slight exceedence of the provisional molybdenum guideline for 0-5 cm soils. No guideline exceedences were found in 1984. As there was no significant relationship between element concentrations and distance from the gold mines in 1986, the guideline exceedences for copper and molybdenum do not appear to be related to mining operations.

CONCLUSIONS

A terrestrial assessment survey was conducted in June, 1986 near the Hemlo gold mines. This study revealed that levels of aluminum, antimony, arsenic, barium, iron, mercury, molybdenum and vanadium increased substantially in lichens, moss, and tree foliage from concentrations recorded in 1984, before the mines were operating. The main source of this contamination appears to have been operations at Lac Minerals Limited. Blasting of rock during site construction and during open-pit mining at this mine was the probable cause of this situation. As site construction at Lac is now completed, and surface ore now exhausted, no further surface blasting is expected.

To confirm that there are no residual concerns about air quality around the Hemlo mines, a small scale follow-up survey will be carried out in 1988.

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2. Ontario Ministry of the Environment, 1983. Field investigation procedures manual. Phytotoxicology Section, Air Resources Branch.

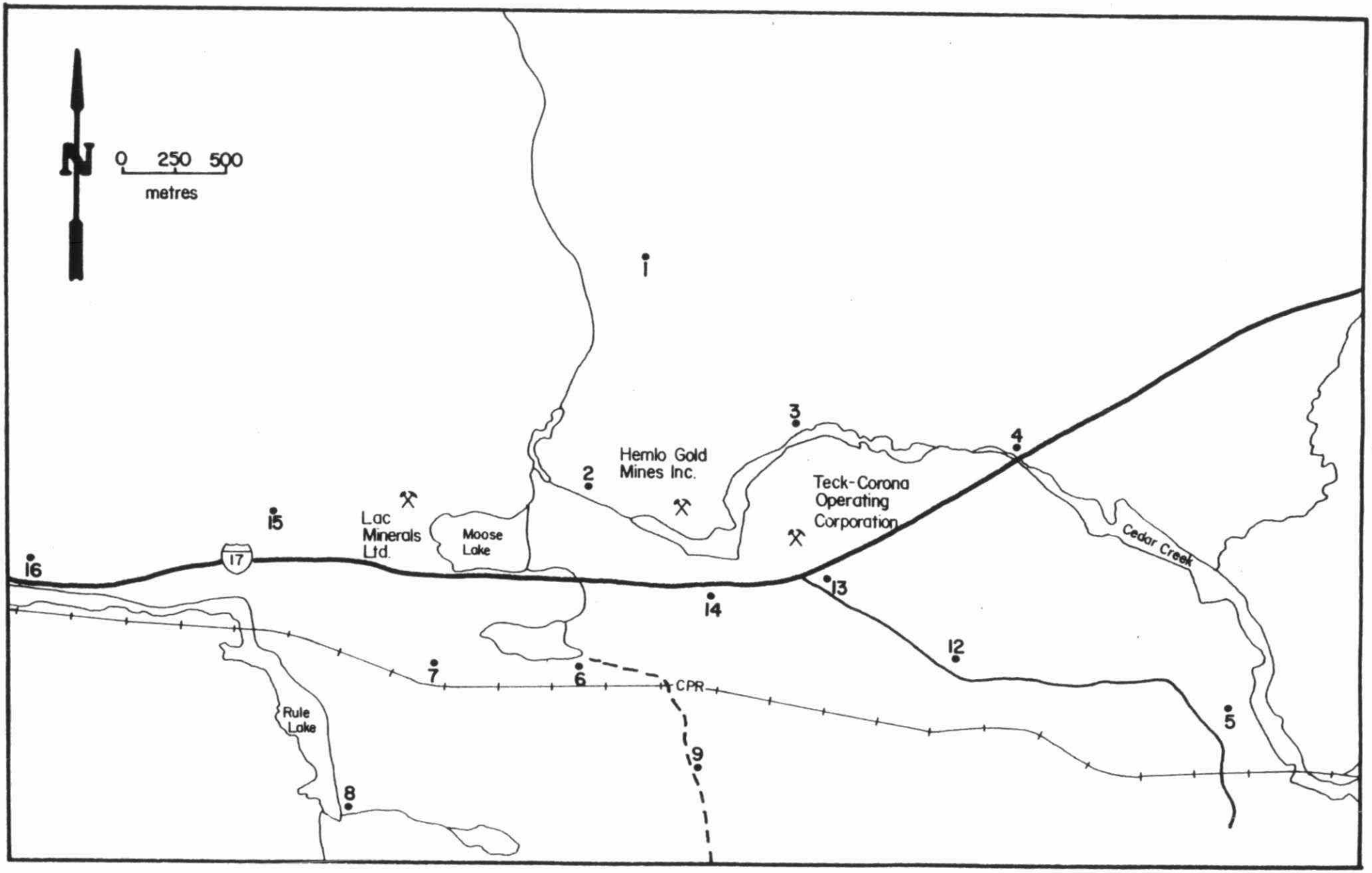

Figure 1. Vegetation and soil sampling sites, Hemlo, June 4-5, 1986.

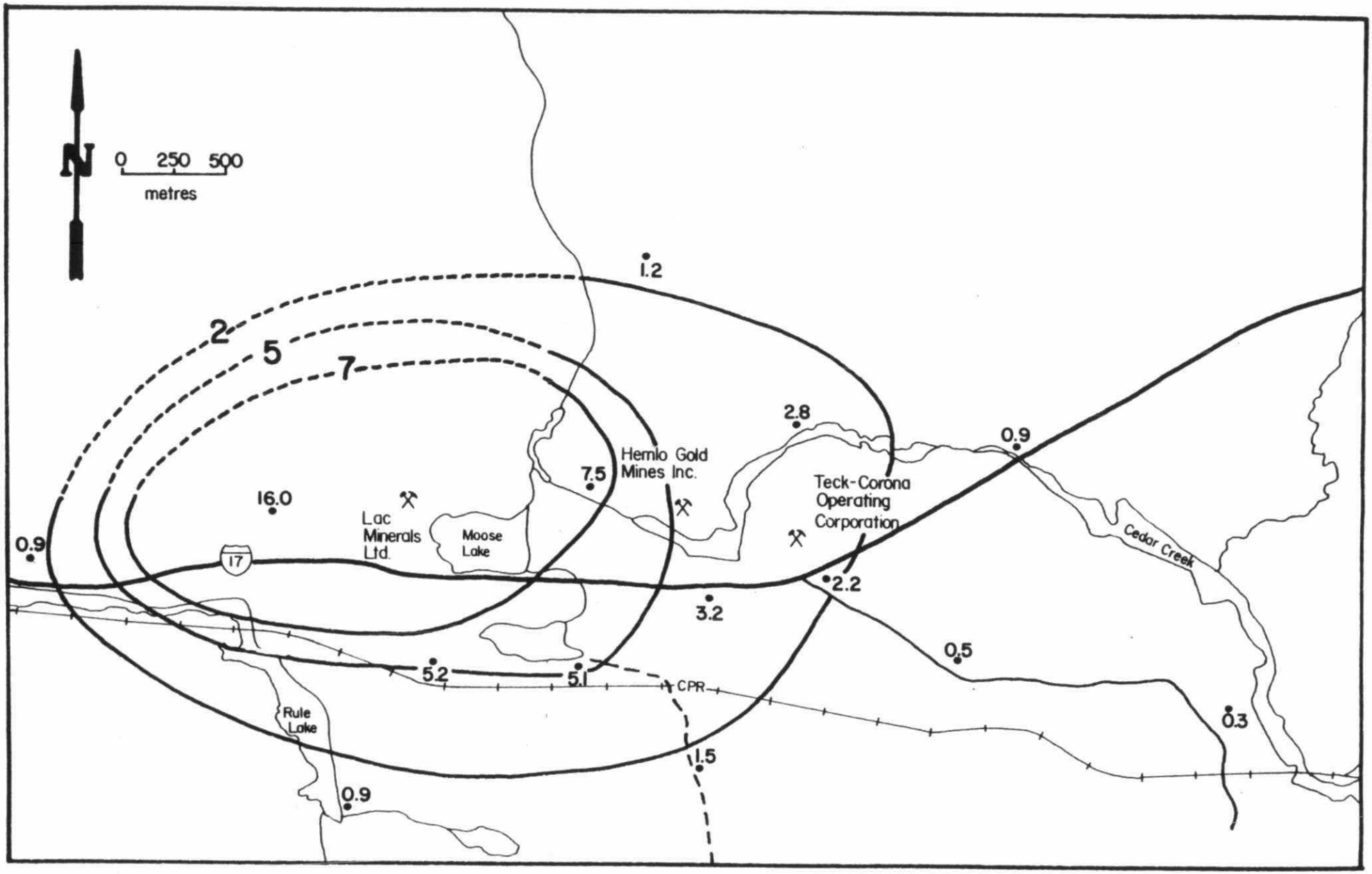

Figure 2. Levels of arsenic (µg/g, dry weight) in Pleurozium schreberi in the vicinity of Hemlo gold mines, June 4-5, 1986.

Table 1. Concentrations of selected elements in vegetation near the Hemlo gold mines, 1986. All values are in μg/g, dry weight.

Plant species	Mean and range	Element[a] Al	Sb	As	Ba	Cd	Cu	Fe	Hg	Mo	Ti	V	Zn
White spruce (1-year old)	Maximum	240	1.60	1.30	140	0.2	4.0	310	0.32	6.0	24	1.0	110
	Mean	87	0.43	0.28	73	<0.1	2.7	110	0.09	1.9	8	<1.0	68
	Minimum	21	0.10	<0.10	26	<0.1	1.9	42	<0.03	<0.5	2	<1.0	36
	Std. dev.[b]	71	0.54	0.46	34	0.1	0.7	92	0.11	2.5	8	0.2	23
White spruce (2-year old)	Maximum	310	1.10	1.40	140	0.2	4.0	380	0.39	7.1	38	2.0	130
	Mean	110	0.30	0.29	78	<0.1	2.9	140	0.09	1.3	11	<1.0	81
	Minimum	24	0.10	<0.10	22	<0.1	2.0	61	<0.03	<0.5	3	<1.0	37
	Std. dev.	94	0.37	0.50	35	0.1	0.8	120	0.12	2.4	12	0.5	33
Black spruce (1-year old)	Maximum	220	3.10	1.40	130	0.1	4.0	340	0.40	6.6	18	1.0	77
	Mean	93	0.61	0.24	67	<0.1	2.7	130	0.09	1.3	8	<1.0	39
	Minimum	42	<0.10	<0.10	20	<0.1	2.0	58	<0.03	<0.5	2	<1.0	26
	Std. dev.	57	0.96	0.44	37	0.0	0.7	93	0.12	2.0	6	0.2	16
Black spruce (2-year old)	Maximum	260	2.60	1.30	140	0.1	4.0	360	0.41	5.3	29	2.0	75
	Mean	110	0.51	0.19	76	<0.1	2.6	160	0.11	1.0	9	<1.0	49
	Minimum	54	<0.10	<0.10	29	<0.1	2.0	74	0.04	<0.5	2	<1.0	32
	Std. dev.	72	0.80	0.41	40	0.0	0.7	100	0.12	1.6	9	0.5	15

Table 1. Continued

Plant species	Mean and range	Element[a] Al	Sb	As	Ba	Cd	Cu	Fe	Hg	Mo	Ti	V	Zn
Pleurozium schreberi (feather moss)	Maximum	2900	21.00	16.00	590	0.9	16.0	3000	5.40	77	260	11	150
	Mean	1500	3.36	3.07	220	0.6	9.2	1700	0.89	15	130	6	81
	Minimum	750	0.20	0.30	53	0.4	0.8	820	0.13	<1	47	3	50
	Std. dev.	600	5.16	4.04	160	0.2	3.4	700	1.32	20	66	3	27
Evernia mesomorpha (lichen)	Maximum	1700	7.40	7.00	370	0.7	9.0	2200	6.11	18.0	190	7	68
	Mean	910	1.66	1.39	83	0.4	5.7	1200	0.95	3.3	90	3	43
	Minimum	400	0.10	0.20	20	0.2	4.0	440	0.24	<0.5	38	2	33
	Std. dev.	310	2.08	1.64	86	0.1	1.5	480	1.52	4.3	41	1	9
Usnea sp. (lichen)	Maximum	990	7.70	3.40	230	0.7	7.0	1200	1.60	10.0	85	4.0	68
	Mean	420	1.11	0.73	61	0.5	4.2	500	0.47	1.9	37	1.8	46
	Minimum	190	<0.10	0.10	23	0.4	3.0	200	0.22	0.5	10	1.0	32
	Std. dev.	180	1.88	0.82	51	0.1	1.2	240	0.33	2.4	19	0.8	10

[a] Contaminant guidelines have not yet been developed for coniferous foliage, mosses or lichens.

[b] Standard deviation of the mean.

Table 2. Levels of aluminum, antimony, arsenic, barium, iron, mercury, molybdenum and vanadium (μg/g, dry weight) in Pleurozium schreberi, near the Hemlo gold mines, 1984 and 1986.

	Aluminum		Antimony		Arsenic		Barium		Iron		Mercury		Molybdenum		Vanadium	
Site	1984	1986	1984[a]	1986	1984	1986	1984	1986	1984	1986	1984	1986	1984	1986	1984	1986
1	1100	920	<0.3	1.1	0.4	1.2	62	140	820	1200	0.13	0.38	0.6	7.3	3	4
2	1500	2900	<0.3	6.7	0.8	7.5	160	480	1300	2800	<0.01	2.00	0.6	42.0	3	11
3	1500	2100	<0.3	1.9	0.6	2.8	78	310	900	2500	0.15	0.59	<0.5	21.0	4	10
4	750	1300	<0.3	0.6	0.3	0.9	69	54	710	1700	0.12	0.18	<0.5	0.9	1	5
5	490	750	<0.3	0.3	0.4	0.3	41	53	510	1000	0.13	0.36	<0.5	1.4	2	3
6	530	1700	<0.3	5.1	0.4	5.1	72	280	650	1600	0.10	1.20	<0.5	22.0	2	6
7	690	1400	<0.3	6.1	0.5	5.2	80	340	840	1900	0.08	1.40	0.8	20.0	2	6
8	1300	1300	<0.3	1.0	0.4	0.9	85	130	830	1300	0.17	0.31	2.0	2.7	2	5
9	620	1500	<0.3	1.8	0.4	1.5	120	150	560	1500	0.13	0.29	<0.5	6.0	3	6
12	540	760	<0.3	0.4	0.4	0.5	87	94	560	820	0.08	0.16	<0.5	2.2	2	3
13	1200	2100	<0.3	0.7	0.8	2.2	80	160	1300	2700	0.12	0.28	<0.5	7.0	3	10
14	2100	1500	<0.3	4.1	0.5	3.2	41	410	830	1600	0.06	1.10	<0.5	19.0	3	7
15	1700	2300	<0.3	21.0	0.6	16.0	88	590	1300	3000	0.17	5.40	<0.5	77.0	3	10
16	1600	1100	<0.3	1.9	0.7	0.9	55	81	1200	1300	0.02	0.33	<0.5	6.0	3	4
Controls	840	1100	<0.3	0.6	0.4	0.4	110	130	600	1100	0.14	0.16	<0.5	1.4	2	4

[a]All antimony results for 1984 were erroneously reported below the instrument detection limit of 0.3 μg/g, dry weight.

Table 3. Correlation matrix of selected parameters in Pleurozium schreberi near the Hemlo area gold mines, June 5,1986.

	Al	Sb	As	Ba	Cd	Cu	Fe	Hg	Mo	Ti	V	Zn
Sb	0.54*											
As	0.67*	0.98*										
Ba	0.76*	0.83*	0.88*									
Cd	0.58*	0.17	0.25	0.38								
Cu	0.26	0.24	0.31	0.38	0.24							
Fe	0.93*	0.61*	0.72*	0.73*	0.58*	0.38						
Hg	0.56*	0.99*	0.98*	0.84*	0.22	0.25	0.64*					
Mo	0.71*	0.96*	0.98*	0.92*	0.32	0.24	0.74*	0.97*				
Ti	0.81*	0.36	0.48	0.47	0.60*	0.31	0.92*	0.38	0.50			
V	0.96*	0.51	0.63*	0.75*	0.60*	0.33	0.96*	0.54*	0.68*	0.88*		
Zn	0.15	-0.32	-0.30	-0.06	0.48	-0.08	0.05	-0.31	-0.25	0.16	0.23	
Dist-LM[1]	-0.60*	-0.62*	-0.66*	-0.75*	-0.07	-0.25	-0.54*	-0.59*	-0.66*	-0.32	-0.55*	0.03
Dist-LMP[2]	-0.67*	-0.32	-0.43	-0.69*	-0.20	-0.48	-0.53*	-0.31	-0.44	-0.40	-0.64*	-0.20
Dist-NM[3]	-0.55*	-0.01	-0.14	-0.45	-0.34	-0.48	-0.44	-0.02	-0.18	-0.48	-0.59*	-0.33
Dist-TC[4]	-0.32	0.24	0.11	-0.14	-0.32	-0.47	-0.26	0.21	0.08	-0.42	-0.40	-0.39

*Denotes a significant correlation for pairs of parameters at the 95% confidence level.
[1]Dist-LM = Distance from sampling sites to the headframe of Lac Minerals Limited.
[2]Dist-LMP = Distance from sampling sites to centre of Lac Minerals Limited open pit.
[3]Dist-NM = Distance from sampling sites to the headframe of Hemlo Gold Mines Inc.
[4]Dist-TC = Distance from sampling sites to the headframe of Teck-Corona Operating Corporation.

Table 4. Levels of selected elements, organic matter and pH in two depths of soil near the Hemlo gold mine, 1986. All values are in μg/g, dry weight, except organic matter which is reported as percent, dry weight.

	Al	Sb	As	Ba	Cd	Cu	Fe	Hg	Mo	Ti	V	Zn	OM[a]	pH
Soil (0–5 cm)														
Maximum	13000	0.20	3.50	94	0.5	290	14000	0.15	2.2	5000	47	91	35	7.4
Mean	6800	<0.10	1.63	50	<0.2	84	7800	0.07	<1.0	3900	26	43	16	5.0
Minimum	2300	<0.10	0.30	28	<0.2	21	2400	<0.03	<1.0	2700	10	14	4	3.9
Std. dev.	3000	0.04	1.00	18	0.1	65	3500	0.04	0.6	660	10	21	10	0.8
Contaminant[b] guidelines	–	1	10	–	3	60	35000	0.15	2[c]	–	70	500	–	–
Soil (5–10 cm)														
Maximum	15000	0.10	3.80	54	<0.2	94	23000	0.04	2.4	5300	75	77	13	7.7
Mean	9600	<0.10	1.32	32	<0.2	40	12100	<0.03	<1.0	4000	39	30	6	5.0
Minimum	4600	<0.10	0.70	14	<0.2	17	5500	<0.03	<1.0	1600	23	7	3	4.3
Std. dev.	3400	0.03	0.75	11	0	21	4900	0.01	0.6	1000	15	19	3	0.8

[a] OM = Organic matter (determined by loss-on-ignition).
[b] Applies only to 0–5 cm soil.
[c] Provisional guideline estimated from limited results, pending additional data.

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